GROWTH OF PLANTED RED AND WHITE PINE IN OHIO AND INDIANA

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This is a report on the rate of growth of white pine (*Pinus strobus* L.) and red pine (*Pinus resinosa* Ait.) planted on old fields within the unglaciated regions of Ohio and central Indiana. Growth is studied in relation to soil and topography.

The study area is confined to the Muskingum-Wellston-Zanesville soil association (16)[2/] (frontispiece); the results obtained should not be applied elsewhere except on a tentative basis. Table 1 (Appendix) shows the composition, age, and general location of the plantations.

METHODS

One hundred circular plots supplied data for this study: 1/10-acre plots were used in young plantations and 1/5-acre plots in older plantations so that the number of trees would be nearly the same for all plots. Plots were located in plantations of red or white pine alone, mixtures of the two, or mixtures of one or the other and some other species. Other species include yellow-poplar (*Liriodendron tulipifera* L.) and Scotch (*Pinus sylvestris* L.), Virginia (*Pinus virginiana* Mill.), and shortleaf (*Pinus echinata* Mill.) pines. All trees were tallied by species, crown class, and 1-inch diameter class. The total heights of 5 dominant, 5 codominant, and 5 intermediate trees of each species were measured to the nearest foot in each plot. Diameters of the same trees were recorded to one-tenth of an inch. Enough increment borings were made 8 inches above the ground to determine the age of each plantation. The original spacing was determined and thinnings or other occurrences were noted.

Each plot was on a single soil type of more or less uniform A horizon thickness. The thickness of the A horizon was measured, samples of the A horizon and subsoil were collected, and the soil profile was described. The aspect, slope, and position of plot between ridge and stream were determined.

1/ Soil Scientist (deceased July 1952), and Forester-in-Charge, respectively, Buckeye Research Center.

2/ Numbers in parentheses refer to Literature Cited, p. 10.

Soil samples were allowed to air-dry in the laboratory and were then sieved to remove particles larger than 2 millimeters in diameter. Mechanical analyses (2) were made and moisture equivalent[3] and moisture content at permanent wilting[4] were determined. Permanent wilting percentage was determined by germinating and growing about 100 wheat plants in two-thirds of a pint of soil. When the plants became 8 inches tall, the soil surface was sealed from the atmosphere with paraffin. Permanent wilting was marked by total collapse of all plants, curling of the blades, and a slight yellowing of the foliage.

ANALYSIS OF GROWTH MEASUREMENTS

The average height growth of white and red pines is shown in figure 1. The curves are based on measurements taken from about

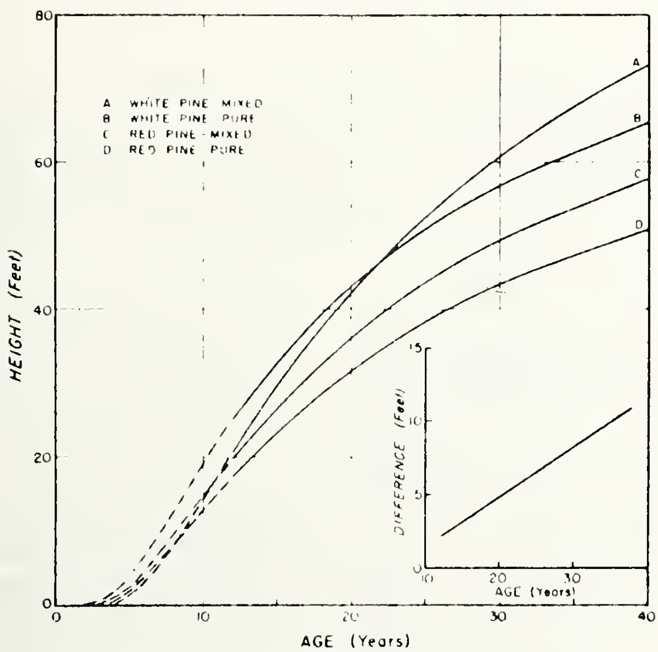

Figure 1.--Height growth of dominant and codominant white and red pines in mixtures with other species and in pure plantations. Insert shows height advantage of white pine over red pine in plantations where the two were mixed.

1,500 trees and show the height of the average dominant or codominant tree by species for mixed and pure plantations.

The differences between the height-growth curves are significant. Dominant or codominant red pines grow more rapidly in height in mixed stands. The advantage over pure stands persists for at

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3/ The water content of soil that has been subjected to a centrifugal force of 1,000 times gravity in a soil centrifuge for 30 minutes (11).

4/ The moisture content of the soil at the time when the leaves of plants growing in the soil first become permanently wilted (11).

least 30 years and perhaps longer. Early growth of white pine, however, is retarded as a result of mixing. But this effect soon disappears because the growth rate of dominants and codominants increases. After 20 years, the average dominant or codominant white pine in a mixed planting is as high as a similar tree in a pure plantation; thereafter such trees are taller in the mixed plantations. These differences in behavior are reflected in the site-index curves.

White pine grew more rapidly in height than red pine (except possibly during the first 10 years) as may be seen from the height-age curves, although the average planting site was the same for both species. Twenty-two plantations studied were composed of nearly equal parts of each species; usually the species were in alternate rows. In 21 of the 22 (fig. 1 - insert), white pine was taller than the red pine, and the height difference increased with age at the same rate and in the same amount as in the more general cases represented by the height-age curves based on pure and mixed plantations. Thus, for the plantations examined, it evidently was not the practice to plant a particular species on the better sites.

The diameter-growth pattern of both species closely follows that for height growth (fig. 2). White pine outgrows red pine in diameter (dominant and codominant classes) except while very young. Mixing white pine with other species does not increase diameter growth. However, red pine grows faster in diameter when mixed with other species.

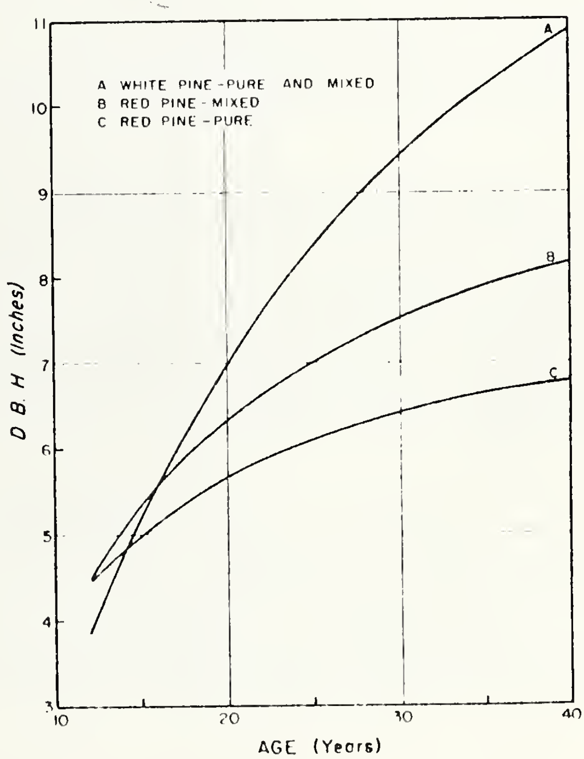


Figure 2.--Diameter growth of dominant or codominant white and red pines in mixtures with other species and in pure plantations.

Site-quality standards can be established by the use of site-index curves. Before site-index curves are prepared, however, it is well to find whether factors other than species or plantation composition influence the growth curve. Among the many potential influences, site quality itself and plantation density could affect the shape of growth curves. Also, by chance, mixed plantings may have been found on better sites than pure plantings, or one species may have been planted on better sites than the other.

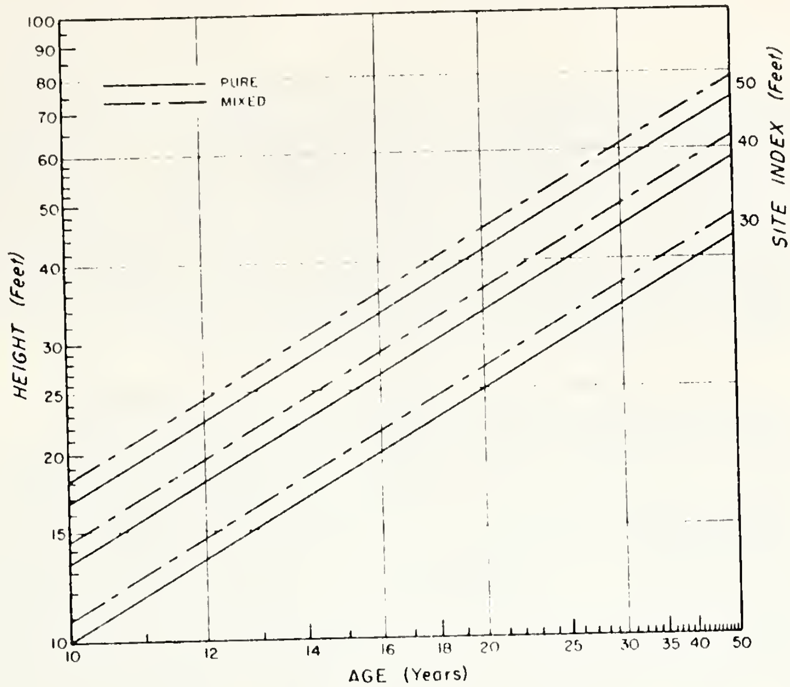
The effect of site quality was tested by comparing height-growth curves of plantations having tall trees with those of plantations having short trees. This comparison showed that the height-growth curves do not vary perceptibly between good and poor sites. The influence of density on height growth was also studied (3) and found to be negligible. Furthermore, the height-age curves for pure and mixed plantations differ in slope after the effects of soil factors on height growth are statistically removed.

The site-index curves of figures 3 and 4 have been prepared in light of the foregoing facts. The index is the total height in feet of the dominant or codominant tree of average basal area among trees of those classes at 25 years of age. Two sets of site-index curves are required for each species so that differences in height growth resulting from plantation composition can be corrected. If this were not done, a given site would have two indices for the same species. It should be noted that the site-index curves for pure and mixed white pine stands do not have the same slope (on a logarithmic scale) (fig. 3) because the ratio of the growth rate in pure plantations to that in mixed plantations is not constant. The red pine site-index curves, however, are shaped the same over the age range studied.

The mortality rate in white pine plantations during the first 35 years is about three times that in the red pine. If planted 6 by 6 feet, about 900 white pines or 300 red pines per acre will probably die in a 35-year period. The great difference in the mortality rate may partly explain the difference between the diameter growth of the two species. Overcrowded white pine trees die, but red pines stagnate; red pines that appear to be headed toward suppression when very young survive to reach the level of the upper canopy.5/

5/ A. G. Chapman, in a letter to the director of the Central States Forest Experiment Station dated April 17, 1944, wrote "As has been my contention for years...red pine stagnates at an earlier age than white pine for the very simple reason that little crown differentiation is ever expressed. White pine on the other hand demonstrates as good differentiation as one can find in any species."

Figure 3.--Site-index curves for white pine in pure and mixed plantations.



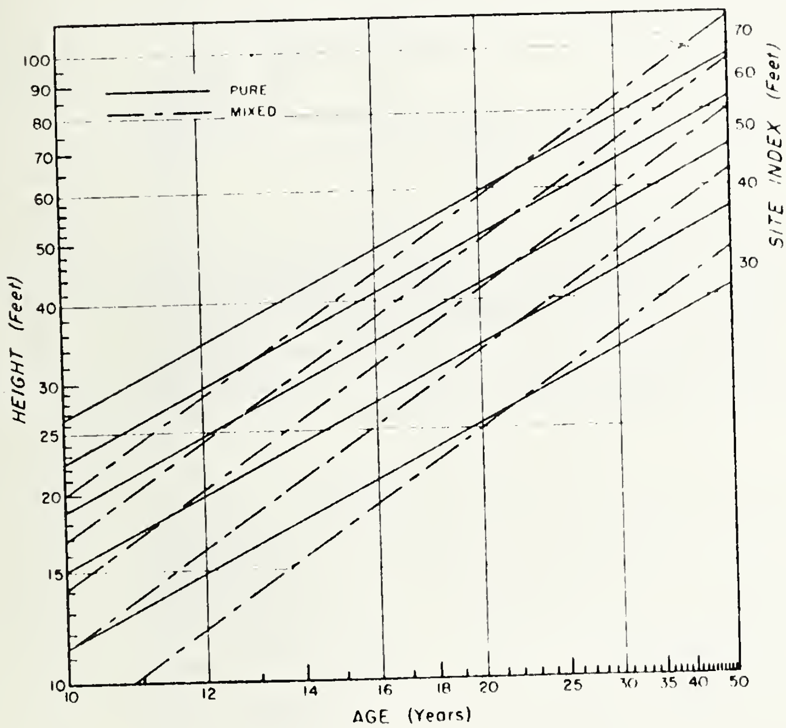


Figure 4.--Site-index curves for red pine in pure and mixed plantations.

Although no special data on self-pruning were taken in this study, the writers observed that self-pruning of both red and white pine is poor. It is common to find branch stubs still attached to the lower bole of 30-year-old white pines. The stubs on red pine are less conspicuous because they are shorter, but they appear to be about as persistent. Pruning crop trees to a height of one log appears desirable. White pine should be so pruned before the plantation is 20 years old (sooner on the better sites).

RELATION OF SITE INDEX TO SOIL AND TOPOGRAPHY

The rate of growth of forest trees often has been correlated with the thickness of the A horizon (1, 4, 6, 7, 12, 13). Both white and red pine are decidedly responsive to changes in the thickness of this horizon (fig. 6 - Appendix). A 1-inch increase in the thickness of the horizon in the 5- to 7-inch range results in a greater increase in site index than does an equal increase in the 10- to 12-inch range. This should be expected because the percentage increase is less in the thicker horizons.

Both species appear to grow slower where the surface and subsoil are finer in texture as measured by the percentage of silt and clay (fig. 7 - Appendix). However, the dominant soil types of the region are fine in texture; the coarser soils are poorly represented. In other regions where the soils of planting sites are very sandy, both species grow or survive better on finer textured soils (9, 10, 15). White pine appears to be more sensitive to soil texture differences than does red pine. Soil - site-quality curves based on A-horizon thickness and texture are shown in figure 5.

Growth of both red and white pine seems to be related to the moisture equivalent and permanent wilting percentage (figs. 8 and 9 - Appendix). The site-index - moisture-equivalent curve closely follows the pattern of the site-index - texture curve. This is not surprising because texture has an important influence on moisture equivalent. Texture also affects the permanent wilting percentage and soil aeration.

Topography has often (1, 5, 6, 7) proved to be a useful guide in estimating site quality. However, aspect, topographic position, and slope are not useful in estimating the site quality of old fields for the growth of red and white pines in this region. The fact that all plantations examined were on old fields has a bearing on this. For to become an old field the land must have been suitable for agriculture at one time or other. Therefore the most adverse of all topographic possibilities could not be sampled. Growth of white oak, sampled over a wider range of slopes and aspects, was found to be related to topography in the region (7).

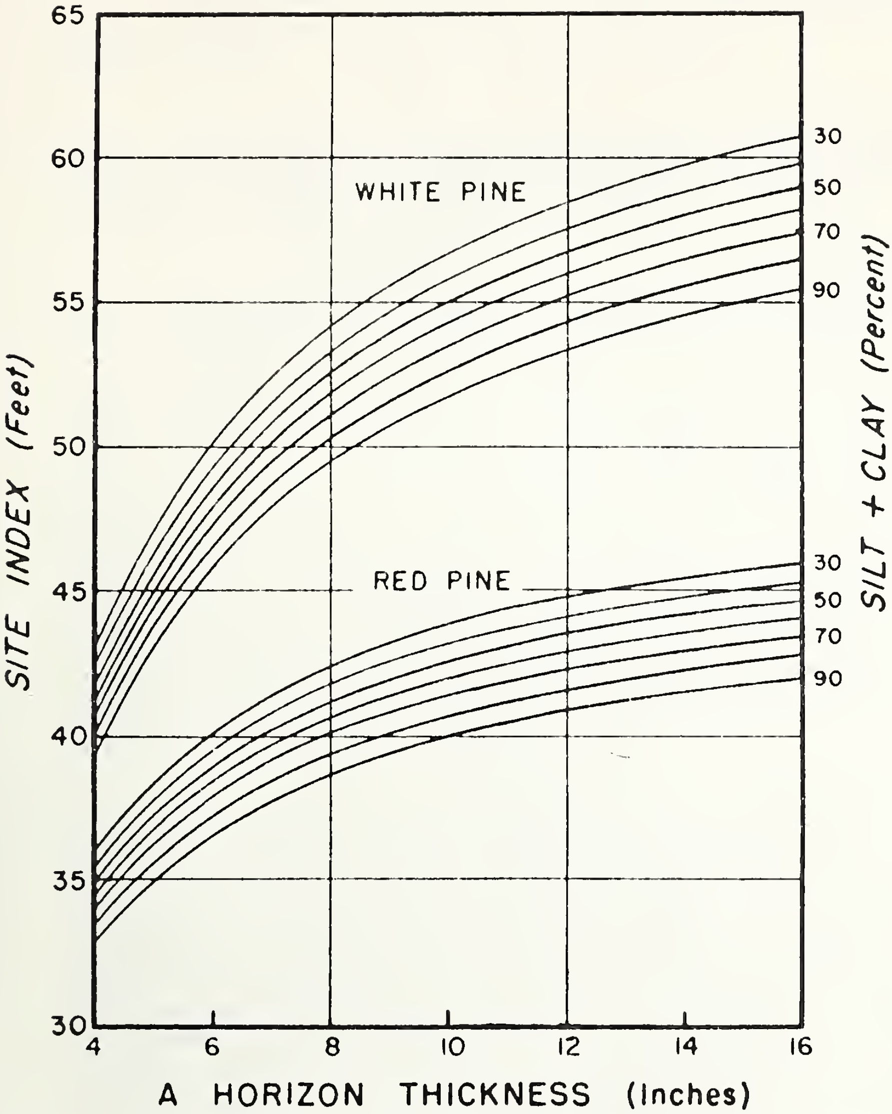


Figure 5.--Soil - site-index curves for planted pines.

GROWTH IN OTHER REGIONS

Comparing tree-growth rates between regions may be useful as well as interesting to the forest land owner who is contemplating planting pine. A few comparisons follow.

White pine grows more than twice as fast in this region (Ohio and Indiana) as in the Lake States (14). Red pine grows equally well here or in Connecticut (10), but it grows about one-third slower (14) in the Lake States.

White pine planted in the unglaciated regions of Ohio and central Indiana grows about as rapidly, for about 25 years, as loblolly pine does in natural stands on the Piedmont plateau of North Carolina (4) and nearly as rapidly as loblolly pine growing on the well drained soils found in the coastal plain region of Virginia and the Carolinas (6). At age 30, white pine in this region is about 6 feet shorter than longleaf pine (*Pinus palustris* Mill.) grown on imperfectly or poorly drained soils of the Atlantic coastal plain (12) and is as tall as longleaf pine (not turpentined) growing on well drained soils in the northern portion of its range (12). These comparisons may be somewhat startling at first, but are not too surprising if note is made of the fact that the average site index for white oak in southeastern Ohio (7) is only 6 feet lower than the average site index for shortleaf pine grown in the Piedmont plateau of North Carolina (1).

Young et al. (17) observe that second-growth white pine in Maine grows more rapidly where the A horizon is thin than where it is thick. Superficially their observations seem at odds with those made in Ohio and Indiana However, the A horizon of the soils of Maine are strongly podzolized and probably contain very few roots while the A horizons of the soils in the unglaciated region of Ohio and central Indiana are the zones of high root concentrations (8). In effect, the A horizon may act as a barrier to root extension (and possibly to aeration in the root zone) in the podzols of Maine, but the same horizon (in name only) is a zone of high root concentration in this region. Under these circumstances, the interregional comparisons might more properly be made between B horizons on one hand and A horizons on the other.

Interregional comparisons between the soil factors affecting tree growth can be meaningful if the regions compared are similar in their climate, topographic characteristics, and their climax forest. These conditions are rarely satisfied. However, the northern portion of the Piedmont plateau is quite similar to the unglaciated region of Ohio and central Indiana. Coile (4), working in the former region, found that loblolly and shortleaf pines grew more rapidly where the A horizon was thick and where water in the subsoil was readily available to plants. His results are similar to

those obtained in this study. The growth of loblolly or shortleaf pine was not found to be related to topography in the Piedmont nor is growth of white or red pine related to topography in this region.

SUMMARY

The growth of red and white pines planted on old fields in the unglaciated regions of Ohio and central Indiana was studied in relation to soil and topography. The height attained by the average dominant or codominant tree was 51 feet for white pine and 38 feet for red pine 25 years after planting. The white pines of these crown classes were 8 inches in diameter breast high and the red pines 6 inches in diameter at that age. Red pine grew more rapidly in height and diameter when mixed with other species. For a time white pine grows more slowly in height when mixed with other species, but growth accelerates, and by the twentieth year trees in the mixed plantings equalled those of pure plantations in height, and thereafter were taller. Plantation composition did not affect the diameter growth of white pine.

Site quality for both species increased as the soil became coarser in texture and declined as the moisture equivalent and permanent wilting percentage of both the A and B soil horizons increased. The thickness of the A horizon had the greatest influence on the rate of height growth of both species; site index was high when the A horizon was thick. Topography did not appear to influence the growth of either species. All things considered, growth of red and white pine in Ohio and Indiana compared favorably with growth of these and other pines in other regions.

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APPENDIX

Table 1.--Number of plantations examined by composition, location, and age

Composition of plantations	Location and age (years)					Total
	Ohio			Indiana		
	12-19	20-29	30-41	12-19	20-29	
White pine - pure	3	0	5	2	1	11
White pine - mixed	13	4	12	0	2	31
Red pine - pure	12	6	9	1	1	29
Red pine - mixed	15	4	8	0	2	29
Total	43	14	34	3	6	100

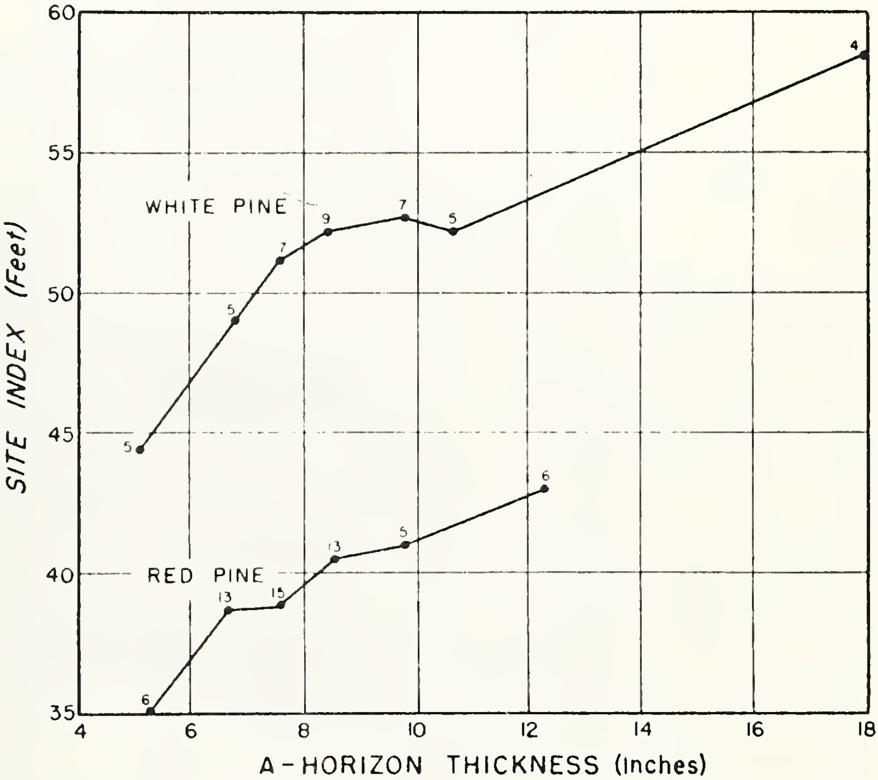

Figure 6.--Relation of site index to the thickness of the A horizon.

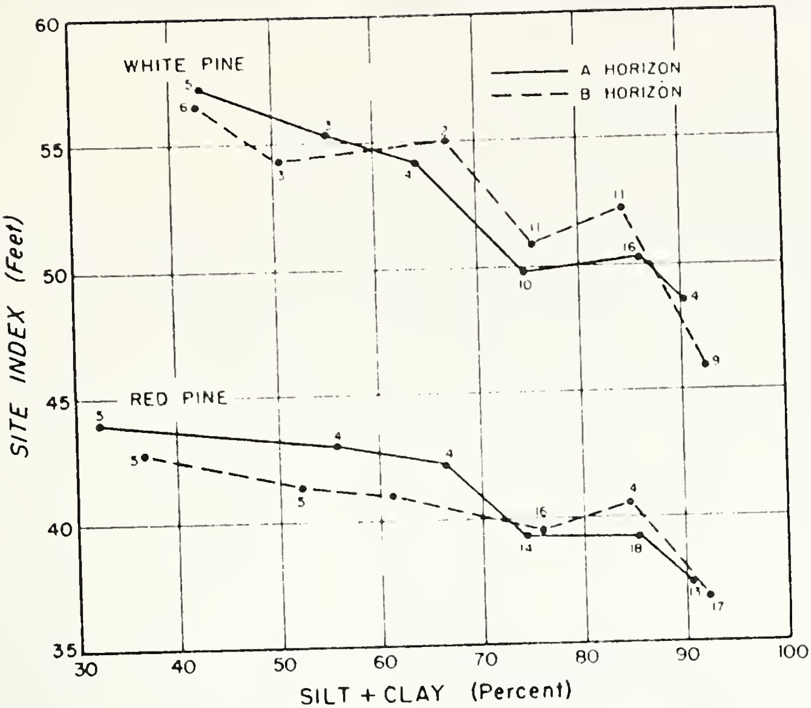

Figure 7.--Relation of site index to percent silt and clay in the A and B horizons.

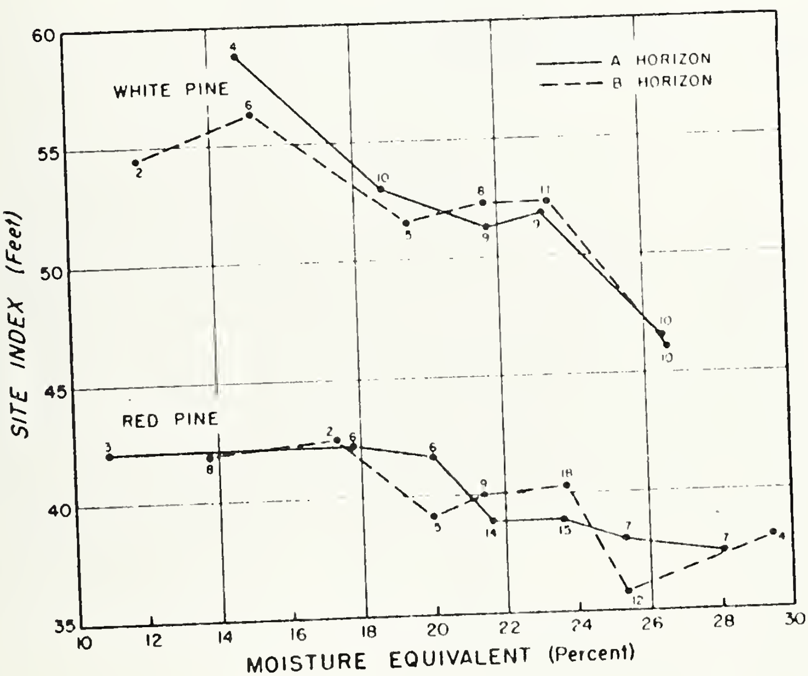

Figure 8.--Relation of site index to moisture equivalent in the A and B horizons.

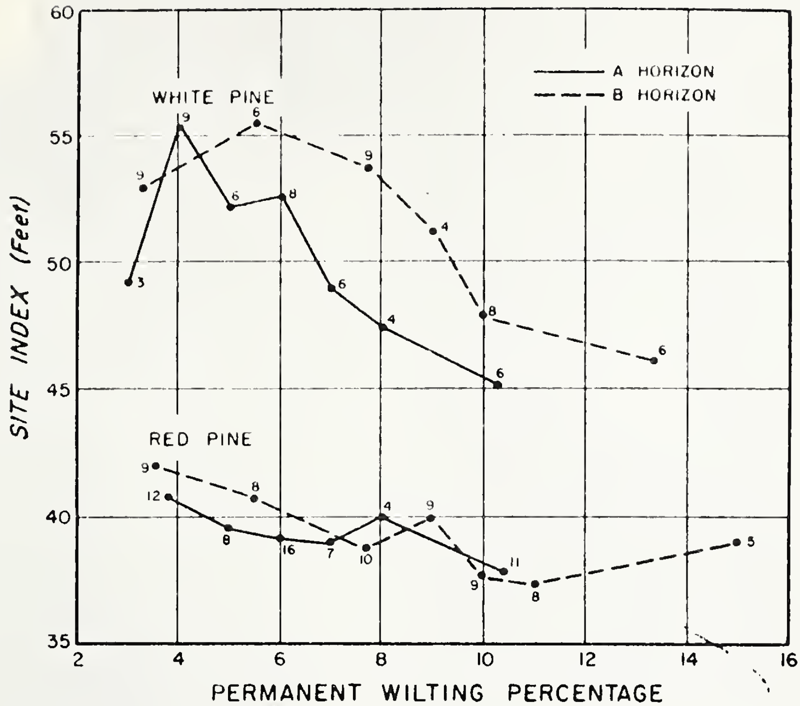

Figure 9.--Relation of site index to permanent wilting percentage (directly determined) in the A and B horizons.